(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 624 049 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94106578.1**

(51) Int. Cl.^{5}: **H04R 9/06**, H04R 9/02

(22) Date of filing: **27.04.94**

(30) Priority: **28.04.93 JP 102308/93**
04.06.93 JP 134493/93

(43) Date of publication of application:
09.11.94 Bulletin 94/45

(84) Designated Contracting States:
DE FR GB

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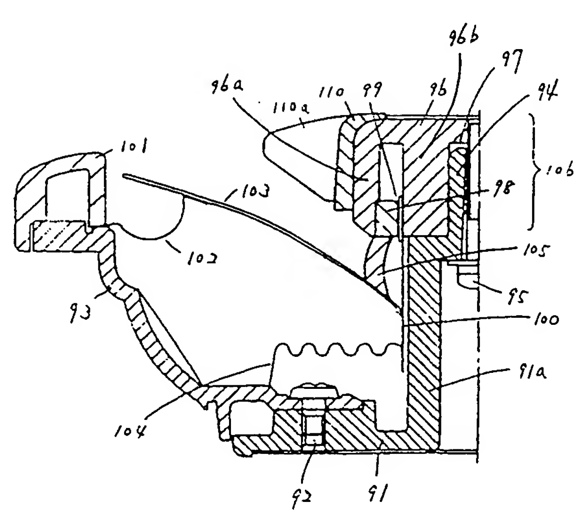
(54) A loudspeaker apparatus.

(57) A yoke, which has an inner peripheral wall formed concentrically with an outer peripheral wall, is used in a magnetic circuit of a loudspeaker. A rare earth element magnet ring is disposed between the outer and inner peripheral walls of the yoke so as to form a magnetic gap there. Thus, a compact, light and powerful magnetic circuit is obtained. The magnetic circuit is disposed in front of a diaphragm, which reduces the thickness of the loudspeaker. By making the projected area of the magnetic circuit on the diaphragm a half or less of the effective area of the diaphragm, deterioration of the performance properties and the quality of reproduced sounds can be avoided. Moreover, a heat dissipator is provided on the yoke so as to prevent any extraordinary or damaging increase in temperature of a voice coil even when large signals are continuously input to the loudspeaker. As a result, performance properties of the loudspeaker can be stabilized and reliability thereof can be enhanced.

Fig. 9



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BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a loudspeaker apparatus for use in various audio devices, and particularly to a thin, compact, and high-performance loudspeaker apparatus.

2. Description of the Related Art:

In recent years, there has been increasing demand for a thin loudspeaker apparatus (simply referred to as a loudspeaker hereinafter) capable of high-quality sound reproduction, due to the diversified uses of loudspeakers and the various conditions under which loudspeakers are used.

Figure **1** shows a cross section of an exemplary configuration for a conventional loudspeaker. Since the loudspeaker is symmetrical about the central axis thereof, only a half portion of the cross section is shown in Figure **1** (referred to as a half cross section hereinafter).

As is shown in Figure **1**, a magnet ring **2** is disposed on a saucer-shaped lower plate **1**. The lower plate **1** has a center pole **1a**. A ring-shaped upper plate **3** is disposed on the magnet **2**. A gap **4** is formed between the center pole **1a** and the upper plate **3**. Thus, the lower plate **1** and the upper plate **3** are layered and connected with each other, with the magnet **2** interposed therebetween, so as to constitute a magnetic circuit **12** including the gap **4**.

On the upper face of the upper plate **3**, a bowl-shaped frame **5** is attached. The outer periphery of a diaphragm **8** is attached to the circular peripheral portion of the frame **5** with an edge **7** interposed therebetween. The edge **7** is fixed onto the circular peripheral portion of the frame **5** by means of a gasket **6**. On the other hand, a voice coil **9** is inserted into the gap **4** without being off-centered. The voice coil **9** is connected with the inner periphery of the diaphragm **8**, and is supported by the frame **5** through a suspension **10** interposed therebetween, the suspension **10** being disposed in the vicinity of the middle portion of the voice coil **9**. Furthermore, a dome-shaped dust cover **11** is attached onto the upper surface of a central portion of the diaphragm **8** so as to prevent dust from entering the interior of the loudspeaker.

Miniaturization and reduction in thickness of a conventional loudspeaker as shown in Figure **1** have been realized mainly by miniaturizing and reducing the thickness of each component element.

Figure **2** shows a half cross section of an exemplary conventional loudspeaker in which thickness has been reduced.

According to this conventional loudspeaker, a magnet cylinder **22** is attached on a lower plate **21**. A saucer-shaped upper plate **23** is further attached on the magnet **22**. The peripheral portion **21a** of the lower plate **21** is formed so as to oppose the upper plate **23** with a gap **24** interposed therebetween. This exemplary loudspeaker is similar to the loudspeaker shown in Figure **1** in that the lower plate **21**, the magnet **22**, and the upper plate **23** constitute a magnetic circuit **32** including the gap **24**.

In the exemplary loudspeaker shown in Figure **2**, a saucer-shaped frame **25** is attached onto the lower face of the lower plate **21**. The peripheral portion of the frame **25** is so formed as to receive a gasket **26**. The outer periphery of a diaphragm **28** is attached to the peripheral portion of the frame **25** by means of an edge **27** which in turn is fixed with the gasket **26**. The inner periphery of the diaphragm **28** is connected with a voice coil **29**. The voice coil **29** is inserted without being off-centered into the gap **24** formed between the lower plate **21** and the upper plate **23**. The diaphragm **28** is supported by the gasket **26** with a suspension **30** interposed therebetween. A dust cover **31** is formed so as to cover the upper plate **23**.

The loudspeaker shown in Figure **2** has a basic structure similar to that of the loudspeaker shown in Figure **1**, but has a reduced thickness by accommodating the magnetic circuit **32** under the diaphragm **28**.

Figure **3** shows a half cross section of an exemplary configuration for a conventional loudspeaker which has an improved configuration as compared with the loudspeaker shown in Figure **1** so as to achieve miniaturization and high performance.

This loudspeaker incorporates a pot-shaped yoke **35** having an outer peripheral wall **35a**, instead of the upper and lower plates used in the loudspeakers shown in Figures **1** and **2**. An inner peripheral wall **35b**, which is disposed concentrically with the outer peripheral wall **35a**, is formed in the yoke **35**. In the vicinity of the inner-upper end of the outer peripheral wall **35a** of the yoke **35** is attached a magnet ring **36**. The magnet **36** may be a magnet which is, for example, composed of rare earth elements and is polarized in a radial direction A voice coil **9** is inserted into a gap **4** formed between the magnet **36** and the inner peripheral wall **35b**. The yoke **35**, the magnet **36**, and the gap **4** constitute a magnetic circuit **37**.

The other component elements of the loudspeaker shown in Figure **3**, e.g. a frame **5** and a diaphragm **8**, are similar to those in the loudspeakers shown in Figure **1**, and descriptions thereof are omitted. Those component elements are indicated by the same reference numerals in

Figure 1.

According to the loudspeaker shown in Figure 3, a compact, light, and high-performance magnetic circuit 37 is realized by using a rare earth magnetic for the magnet 36 in which the rare earth magnet is polarized in the radial direction. As a result, the loudspeaker is miniaturized and has high performance over all.

However, the conventional loudspeakers shown in Figures 1 to 3 have the following problems regarding miniaturization, reduction in thickness, and improvement in sound reproduction quality:

(1) Limits on miniaturization:

According to the configuration shown in Figure 1, one can further miniaturize the loudspeaker by making the tilt of the diaphragm 8 gentler. Alternatively, the loudspeaker can also be miniaturized by reducing the respective thicknesses of the lower plate 1, the magnet 2, and the upper plate 3 so as to reduce the thickness of the magnetic circuit 12 as a whole. However, too gentle a tilt of the diaphragm 8 brings such problems as of the decrease in the upper limit of reproducible frequency in the high frequency region and of uneven frequency characteristics. Moreover, as the thickness of the magnetic circuit 12 is reduced, the movement of the voice coil 9 may be limited and/or the sound-reproduction efficiency may decrease, thus deteriorating the quality of reproduced sounds.

On the other hand, according to the configuration shown in Figure 2, the diaphragm 28 has an upside-down shape called "a reverse cone type" as compared with common loudspeakers, while the thickness of the loudspeaker is reduced. As a result, the pressure of the reproduced sound overly diffuses, thus causing a decrease in the sound reproduction efficiency and deterioration in the reproduction characteristics of the audio signals along the center axis of the loudspeaker. This inevitably limits the usage of the loudspeaker. In addition, the diaphragm 28 is supported less firmly and therefore is likely to become insecure, which disables the loudspeaker from reproducing audio signals of large energy.

(2) Temperature elevation:

According to the configurations of conventional loudspeakers, there is a tendency for the temperature of the voice coil 9 or 29 to gradually increase when input signals of large energy (simply referred to as large input signals hereinafter) are continuously input to the loudspeaker.

In particular, a high-performance loudspeaker such as shown in Figure 3 is likely to receive large input signals in actual use, so that the temperature of the voice coil 9 increases even more drastically. The heat generated by the temperature increase of the voice coil 9 is dissipated through the yoke 35 and/or the magnet 36 in the magnetic circuit 37. However, according to the configuration shown in Figure 3, the yoke 35 and the magnet 36 are miniaturized as a whole, thus such a heat dissipation is restrained. As a result, in extreme cases, the voice coil 9 may be broken down due to the increase in the temperature thereof.

A configuration which can solve the above-mentioned problems is required in order to satisfy the demand for miniaturization, reduction in size, and high performance for the loudspeaker at the same time.

SUMMARY OF THE INVENTION

A loudspeaker apparatus according to the present invention comprises a supporting member having a center pole; a frame, the outer periphery of the frame connected with the supporting member; a yoke having a pot-like shape, the yoke including an outer peripheral wall and an inner peripheral wall, the walls being formed concentrically with each other, the yoke being attached at the top end of the center pole so as to face the supporting member; a magnet attached to the inner side face of the outer peripheral wall; a voice coil inserted into a gap between the magnet and the inner peripheral wall, the voice coil moved along the direction of the center axis of the yoke by interaction between a magnetic field formed by the magnet and a current flowing through the voice coil; and a diaphragm disposed between the supporting member and the yoke so as to surround the center pole, the inner periphery of the diaphragm connected with the voice coil, the outer periphery of the diaphragm connected with the outer periphery of the frame, the diaphragm moving in accordance with movement of the voice coil.

In one embodiment, a projected area of the yoke on the diaphragm is a half or less of the effective area of the diaphragm. Preferably, the yoke acts as an equalizer and has a shape and size sufficient for obtaining an appropriate equalizing effect.

In another embodiment, the magnet is a magnet ring which is polarized in a radial direction. Preferably, the magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

In still another embodiment, the speaker apparatus further comprises a heat dissipating means for dissipating heat generated in the voice coil and the yoke. The heat dissipating means may be a heat dissipating member which has a plurality of heat dissipating fins. Alternatively, the heat dis-

sipating means is a plurality of heat dissipating fins which are formed as part of the yoke.

A loudspeaker apparatus according to the present invention comprises a yoke having a pot-like shape, the yoke including an outer peripheral wall and an inner peripheral wall, the walls being formed concentrically with each other; a frame disposed in front of the yoke, the inner periphery of the frame connected with the yoke; a magnet attached to the inner side face of the outer peripheral wall; a voice coil inserted into a gap between the magnet and the inner peripheral wall, the voice coil moved along the direction of the center axis of the yoke by interaction between a magnetic field formed by the magnet and a current flowing through the voice coil; a diaphragm, the inner periphery of the diaphragm connected with the voice coil, the outer periphery of the diaphragm connected with the outer periphery of the frame, the diaphragm moving in accordance with movement of the voice coil; and a heat dissipating means for dissipating heat generated in the voice coil and the yoke.

In one embodiment, wherein the heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins. Alternatively, the heat dissipating means may be a plurality of heat dissipating fins which are formed as part of the yoke.

In another embodiment, the magnet is a magnet ring which is polarized in a radial direction. Preferably, the magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

Thus, the invention described herein makes possible the advantages of (1) providing a compact, thin, and yet high-performance loudspeaker apparatus capable of high-quality reproduction of an audio signal, and (2) a highly reliable loudspeaker apparatus having stable performance properties in which even when large input signals are continuously supplied thereto, any extraordinary increase in temperature of the voice coil is restrained.

These and other advantages of the present invention will become apparent to those skilled in the art upon reading and understanding the following detailed description with reference to the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure **1** shows a half cross section of an exemplary configuration for a conventional loudspeaker.

Figure **2** shows a half cross section of another exemplary configuration for a conventional loudspeaker.

Figure **3** shows a half cross section of still another exemplary configuration for a conventional loudspeaker.

Figure **4** is a cross-sectional view showing a configuration for a loudspeaker in accordance with a first example of the present invention.

Figure **5** shows a half cross section of a configuration for a loudspeaker in accordance with a second example of the present invention.

Figure **6** is a perspective view of the loudspeaker in the second example of the present invention.

Figures **7A** to **7D** are perspective views showing heat dissipators having different shapes which may be used for a loudspeaker in accordance with the present invention.

Figure **8** shows a half cross section of a configuration for a loudspeaker in accordance with a third example of the present invention.

Figure **9** shows a half cross section of a configuration for a loudspeaker in accordance with a fourth example of the present invention.

Figure **10** is a graph which illustrates the exemplary frequency characteristic of the loudspeaker in accordance with the fourth example of the present invention.

Figure **11** is a graph which illustrates the influence of the size of a magnetic circuit portion on the frequency characteristic of the loudspeaker in accordance with the fourth example of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereinafter, the present invention will be described by way of examples, with reference to the accompanying drawings.

Example 1

Figure **4** shows a cross section of a loudspeaker in accordance with a first example of the present invention.

The loudspeaker shown in Figure **4** includes a disk-shaped supporter **41** instead of the upper plate **1** and the lower plate **3** which conventional loudspeakers typically have. In the center of the supporter **41**, there is integrally formed a center pole **41a** extending toward the front face of the loudspeaker. The supporter **41** and the center pole **41a** may alternatively be formed separately and attached to each other later.

At the top end of the center pole **41a**, a centering pin **43** is formed. It is preferable to fabricate the centering pin **43** with a high precision as to measurements thereof. This is because, as will be described later, a yoke **44** is to be fixed by insert-

ing the centering pin **43** into a center guide hole **45** of the yoke **44**.

The supporter **41** is preferably a non-magnetic material having high physical strength and with a high heat dissipating property. For example, the supporter **41** may be formed by an aluminum die-casting method, a zinc die-casting method and the like. However, if the loudspeaker is to be used without a large signal being input, the supporter **41** may be formed of a heat-resistant resin such as any so-called engineering plastics because the heat dissipating property is not strongly required in such a case.

A frame **42** so configurated as to surround the center pole **41a** is attached to the supporter **41**. The frame **42** should preferably have the same properties as the supporter **41**. It is possible to integrally form the supporter **41** and the frame **42** when both are designed so as to be formed of the same material. This will make it possible to reduce the number of the component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and that the fabrication cost decreases. For example, it is preferable to integrally form the supporter **41** and the frame **42** by an aluminum die-casting method.

The center pole **41a** and the centering pin **43** may have any shape, e.g. a prism, a column, and a cylinder having a hollow portion. However, column shapes are preferable because they are easily fabricated and dissipate heat efficiently.

The yoke **44** has a pot-like shape enclosed by an outer peripheral wall **44a**. In the vicinity of the center of the bottom face of the yoke **44**, the center guide hole **45** surrounded by an inner peripheral wall **44b** is formed. The inner peripheral wall **44b** and the outer peripheral wall **44a** are formed concentrically with each other. In the vicinity of the inner-lower end of the outer peripheral wall **44a** of the yoke **44**, a magnet ring **46** is attached. A voice coil **48** is inserted into a gap **47** between the magnet **46** and the wall surface of the inner wall **44b**. The yoke **44**, the magnet **46**, and the gap **47** constitute a magnetic circuit **53**.

The outer periphery of the frame **42** is connected with the outer periphery of a diaphragm **50** with an edge **49** interposed therebetween. The inner periphery of the diaphragm **50** is connected with the voice coil **48**. One edge of a suspension **51** is further connected with the voice coil **48**. The other edge of the suspension **51** is attached to the frame **42** and is supported on the upper face of the supporter **41**. A flexible dust cover **52** is provided between the diaphragm **50** and the magnet **46**. A ring gasket (not shown) may be attached to the outer periphery of the frame **42**.

In an actual operation of the loudspeaker, a current in accordance with an audio signal to be output flows through the voice coil **48**. The current and a magnetic field formed by the magnet **46** interact with each other so as to produce force by which the voice coil **48** is moved upwards and downwards in the gap **47** (i.e., along the direction of the center axis of the yoke **44**). This movement of the voice coil **48** is transmitted to the diaphragm **50** and consequently, diaphragm **50** vibrates so as to reproduce audio signals.

In the fabrication process of the loudspeaker shown in Figure **4**, the suspension **51**, the diaphragm **50**, and the voice coil **48** are successively disposed around the center pole **41a** formed on the supporter **41**. Next, the respective inner peripheries of the diaphragm **50** and the suspension **51** are fixed to the voice coil **48**, and their respective outer peripheries are fixed to the frame **42**, by using an adhesive, while ensuring that the centers of the diaphragm **50** and the suspension **51** coincide with each other by means of the centering pin **43**. Last of all, the yoke **44**, on which the magnet **46** has been mounted, is fixed by inserting the centering pin **43** into the center guide hole **45** of the yoke **44**.

The yoke **44** is required to have such properties as low magnetic resistance and high heat dissipation, and preferably is composed of iron with a high magnetic permeability. For material of the diaphragm **50**, molded pulp or molded plastic may be typically used. The suspension **51** may be typically made of pressed texture.

As is described above, in the loudspeaker shown in Figure **4**, the magnetic circuit **53**, which conventionally is placed behind the diaphragm **50**, is disposed in front of the diaphragm **50**. Thus, it is made possible to reduce the thickness of the loudspeaker.

The configuration shown in Figure **4** may have an unfavorable effect on performance properties of the loudspeaker and the quality of reproduced sounds if the magnetic circuit **53** is too large. However, the inventors found through experiments that deterioration of the performance properties and the reproduced sounds can be restrained by reducing the projected area of the magnetic circuit **53** (practically, the yoke **44**) on the diaphragm **50** to be a half or less of the effective area of the diaphragm **50**.

In order to satisfy the above-mentioned conditions, a rare earth magnet having a high energy density is used for the magnet **46** in the loudspeaker of the present example. In addition, the magnet **46** is polarized in a radial direction, thereby realizing a compact, light, and very powerful magnetic circuit **53**. Specifically, a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet and the like are preferably used as the magnet **46**. In particular, the neodymium magnet is preferable.

As has been described, in the loudspeaker of the first example of the invention, the thickness of the loudspeaker is reduced by disposing the magnetic circuit **53** in front of the diaphragm **50** as is shown in Figure **4**. In addition, high-quality reproduction of audio signals is realized by optimizing the size of the magnetic circuit **53**. In contrast to the conventional loudspeaker described with reference to Figure **2**, the reduction in thickness of the loudspeaker can be realized without unfavorably affecting the design of the moving system of the loudspeaker. Accordingly, the loudspeaker can be optimized both in terms of the configuration of the moving system and the quality of the reproduced sounds.

Moreover, the magnetic circuit **53** disposed in front of the diaphragm **50** can also function as an equalizer. Taking advantage of this aspect, the frequency characteristics of the loudspeakers can be controlled (this effect will hereinafter be referred to as an "equalizing effect"). As a result, by optimizing the size and shape of the magnet circuit **53** (practically, the yoke **44**), frequency characteristics can be improved especially in middle to high frequency bands, whereby a loudspeaker capable of reproducing sounds with an improved quality can be provided. This equalizing effect will be further described later with reference to the drawings.

Typical dimensions of the supporter **41**, the diaphragm **50** and the yoke **44** are as follows: the diameter of the supporter **41**: 81 mm; the diameter of the center pole **41a**: 24 mm; the height of the center pole **41a**: 50 mm; the diameter of the diaphragm **50**: 135 mm; the diameter of the bottom face of the yoke **44**: 41 mm; the height of the outer and inner peripheral walls **44a** and **44b**: 20 mm.

In the loudspeaker shown in Figure **4**, the flexible dust cover **52** is provided between the magnet **46** and the diaphragm **50** so as to prevent dust, etc. from entering the interior of the loudspeaker. However, such a dust cover **52** is not required if environments permit.

Example 2

A configuration in which improvements are made with a view mainly to reducing the thickness of a loudspeaker was described in Example 1. Hereinafter, a second example of the present invention will be described with reference to Figures **5** to **7**. The loudspeaker of the present example is intended to have an improved heat dissipation property.

Figure **5** shows a half cross section of a configuration for a loudspeaker according to the second example of the present invention.

The loudspeaker shown in Figure **5** incorporates a pot-shaped yoke **61** enclosed by an outer peripheral wall **61a**. An inner peripheral wall **61b** is also formed concentrically with the outer peripheral wall **61a** in the yoke **61**. In the vicinity of the inner-upper end of the outer peripheral wall **61a** of the yoke **61**, a rare earth magnet ring **62** polarized in a radial direction is attached. A voice coil **64** is inserted into a gap **63** between the magnet **62** and the inner peripheral wall **61b**. The yoke **61**, the magnet **62**, and the gap **63** constitute a magnetic circuit **71**.

A bowl-shaped frame **65** is attached to the outer-upper end of the outer peripheral wall **61a** of the yoke **61**. The outer periphery of a diaphragm **68** is connected with the circular peripheral portion of the frame **65** with an edge **67** interposed therebetween, the edge **67** being fixed by means of a gasket **66**. The inner periphery of the diaphragm **68** is connected with the voice coil **64**. The voice coil **64** is further supported by a suspension **69** provided in the vicinity of the center thereof. A dome-shaped dust cover **70** is provided above the central portion of the diaphragm **68** so as to prevent dust from entering the interior of the loudspeaker.

One major feature of the loudspeaker in the present example is a heat dissipator **75** attached on the outside of the yoke **61**. Several dissipating fins **75a** are provided on the heat dissipator **75** so as to increase the surface area, whereby the heat dissipation property is improved.

Figure **6** is a perspective view showing the loudspeaker shown in Figure **5**.

As is described above, the temperature of the voice coil **64** increases when large signals are continuously input to the loudspeaker, and consequently the temperature of the magnetic circuit **71** increases. The loudspeaker shown in Figures **5** and **6** includes a small magnetic circuit **71** utilizing a rare earth magnet polarized in the radial direction. Therefore, the thermal capacity of the magnetic circuit **71** is smaller than that of the conventional loudspeaker, which is likely to cause a temperature elevation therein. However, the heat is effectively dissipated via the plurality of dissipating fins **75a** of the heat dissipator **75** attached on the yoke **61**, so that any extraordinary increase in the temperature of the voice coil **64** is not sustained. As a result, problems concerning the performance properties of the loudspeaker due to increases in the temperature of the voice coil **64** are prevented, and a highly reliable loudspeaker having a stable performance properties is realized.

Figures **7A** to **7D** show examples of the heat dissipator **75** with various shapes that can be suitably used for the loudspeaker in the present example. The heat dissipator shown in Figure **7A** is identical with that shown in Figures **5** and **6**.

The heat dissipator **75** is composed of a material having high thermal conductivity, e.g. aluminum, iron, and zinc alloys. For example, the heat dissipator **75** in the present example is formed by an aluminum die-casting method. The size and shape of the heat dissipator **75** may be designed so as to be optimum based on the size and shape of the loudspeaker. The estimated value for the increased temperature of the voice coil **64**, which would be calculated from the conditions of signals to be input, may also be taken into account for designing the heat dissipator **75**. Accordingly, the shape of the heat dissipator **75** to be used for the loudspeaker of the present example is not limited to those shown in Figures **7A** to **7D**, as long as the heat generated in the voice coil **64** is well dissipated.

Example 3

Hereinafter, a loudspeaker in a third example of the present invention will be described with reference to Figure **8**, which shows a half cross section of the loudspeaker of the present example. In the loudspeaker of the present example, improvements are made with a view mainly to improving the heat dissipation property thereof.

In Example 2, the heat dissipator **75** is attached on the outside of the yoke **61**. Instead of that, a plurality of heat-dissipating fins **80** are integrally formed on the outside of a yoke **61** in this example. The other component elements are similar to those of the loudspeaker in Example 2, and descriptions thereof are omitted.

According to the loudspeaker shown in Figure **8**, the temperature of a voice coil **64** is prevented from increasing extraordinarily, as is the case with the loudspeaker of Example 2. In addition, the heat-dissipating fins **80** and the yoke **61** are formed integrally. Therefore, it is possible to reduce the number of the component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and that the fabrication cost decreases.

Example 4

Hereinafter, a loudspeaker according to a fourth example of the present invention will be described with reference to Figure **9**, which shows a half cross section of the loudspeaker of the present example. In the loudspeaker of the present example, as in Examples 2 and 3, improvements are made with a view to improving the heat dissipation property thereof in addition to the improvements to reduce the thickness of the loudspeaker by disposing the magnetic circuit in front of the diaphragm as in Example 1.

According to a configuration shown in Figure **9**, a disk-shaped supporter **91** having a center pole **91a** in a central portion is used. The center pole **91a** is formed in a cylindrical shape having a hollow portion. A bowl-shaped frame **93** is attached on the supporter **91** by means of screws **92**.

A centering pin **94** is formed at the top end of the center pole **91a**. The centering pin **94**, as well as the centering pole **91a**, has a hollow portion so as to receive a screw **95** for fixing a yoke **96**.

The yoke **96** has a similar configuration to that of the yoke **44** of Example 1, shown in Figure **4**. In other words, the yoke **96** has an inner peripheral wall **96b** so as to form a center guide hole **97**. An outer peripheral wall **96a** is also formed concentrically with the inner peripheral wall **96b**. The yoke **96** is fixed to the center pole **91a** by inserting the centering pin **94** into the center guide hole **97** of the yoke **96**, with use of the screw **95**.

In the vicinity of the inner-lower end of the outer peripheral wall **96a** of the yoke **96**, a magnet ring **98** is attached. A voice coil **100** is inserted into a gap **99** between the magnet **98** and the wall surface of the inner peripheral wall **96b**. The yoke **96**, the magnet **98**, and the gap **99** constitute a magnetic circuit **106**.

By using a rare earth magnet polarized in a radial direction as the magnet **98**, similar to Examples 1 to 3, the magnetic circuit **106** becomes compact, light, and very powerful. Preferably, a neodymium magnet is used.

The outer periphery of the frame **93** is processed so as to receive a gasket **101**, and is connected with the outer periphery of the diaphragm **103**, with an edge **102** interposed therebetween, the edge **102** being fixed by means of a gasket **101**. The inner periphery of the diaphragm **103** is connected with the voice coil **100**. One end of a suspension **104** is further connected with the voice coil **100**, while the other end of the suspension **104** is supported by the frame **93**. A flexible dust cover **105** is provided between the diaphragm **103** and the magnet **98**. However, the dust cover **105** is not a requirement if environments permit.

Moreover, a heat dissipator **110** is attached on the outside of the yoke **96**, as in Example 2. Several heat-dissipating fins **110a** are provided on the heat dissipator **110** so as to improve the dissipation property for heat generated in the voice coil **100** and the magnetic circuit **106**. Particularly in this example, the vibration of the diaphragm **103** stirs air in the neighborhood of the heat dissipator **110**. Thus, the heat dissipation can be enhanced.

The loudspeaker having the above-mentioned configuration has both the features of the loudspeaker in Example 1 and the features of the loudspeaker in Example 2. In other words, the thickness of the loudspeaker is reduced by dis-

posing the magnetic circuit **106** in front of the diaphragm **103**. The magnetic circuit **106** is made compact and powerful by using a rare earth magnet polarized in a radial direction as the magnet **98**. In addition, even when large signals are continuously input to the loudspeaker, the heat dissipator **110** prevents the temperature of the voice coil **100** from any extraordinary or damaging increase.

Moreover, the loudspeaker in the present example can utilize the equalizing effect of the magnetic circuit **106** as in Example 1, shown in Figure **4**. Particular in the present example, the size and shape of the plurality of heat-dissipating fins **110a** of the heat dissipator **110** can be varied so as to control the equalizing effect flexibly. As a result, more varied frequency characteristics than those of the loudspeaker of Example 1 can be obtained.

Figure **10** shows an example of frequency characteristics of the loudspeaker having the configuration according to the present example. The solid line denotes the frequency characteristic (the relationship between frequency and output sound pressure) of the loudspeaker of the present example (the projected area of the magnetic circuit **106** on the diaphragm **103** is 10% of the effective area thereof), whereas the broken line denotes the frequency characteristic of a conventional loudspeaker in which the magnetic circuit is located behind the diaphragm. As is seen from Figure **10**, the loudspeaker of the present example has higher output sound pressure, i.e. output level of the reproduced sound volume, than the conventional loudspeaker, especially in the middle to high frequency bands.

More diversity in the equalizing effect can be attained by varying the thickness, size, and number of the heat-dissipating fins **110a** of the heat dissipator **110**. In addition, the equalizing effect can be further improved by integrally forming the heat-dissipating fins **110a** at the periphery of the heat dissipator **110**.

Attention has to be paid to the fact that such a configuration of the loudspeaker in the present example may have an unfavorable effect on performance properties of the loudspeaker when the projected area of the magnetic circuit **106** on the diaphragm **103** exceeds a half of the effective area of the diaphragm **103**. Figure **11** shows such an unfavorable frequency characteristic obtained when the projected area of the magnetic circuit **106** on the diaphragm **103** is 70% of the effective area of the diaphragm **103**. In Figure **11**, peaks exist in middle frequency band in the frequency characteristic, resulting in less flatness thereof. Such peaks result from interference caused by the reflected sound from the magnetic circuit **106**.

However, as described previously relating to the first example of the present invention, the above unfavorable effect can be avoided by making the projected area of the magnetic circuit **106** on the diaphragm **103** a half or less of the effective area of the diaphragm **103**.

In stead of the heat dissipator **110**, a plurality of heat-dissipating fins may be integrally formed on the outside of the yoke **96**, as in the case of the loudspeaker of Example 3. In that case, it becomes possible to reduce the number of component elements and fabrication steps of the loudspeaker, so that the fabrication process becomes more efficient and the fabrication cost decreases, as in Example 3.

Various other modifications will be apparent to and can be readily made by those skilled in the art without departing from the scope and spirit of this invention. Accordingly, it is not intended that the scope of the claims appended hereto be limited to the description as set forth herein, but rather that the claims be broadly construed.

Claims

1. A loudspeaker apparatus comprising:

   a supporting member having a center pole;

   a frame, the outer periphery of said frame connected with said supporting member;

   a yoke having a pot-like shape, said yoke including an outer peripheral wall and an inner peripheral wall, said walls being formed concentrically with each other, said yoke being attached at the top end of said center pole so as to face said supporting member;

   a magnet attached to the inner side face of said outer peripheral wall;

   a voice coil inserted into a gap between said magnet and said inner peripheral wall, said voice coil moved along the direction of the center axis of said yoke by interaction between a magnetic field formed by said magnet and a current flowing through said voice coil; and

   a diaphragm disposed between said supporting member and said yoke so as to surround said center pole, the inner periphery of said diaphragm connected with said voice coil, the outer periphery of said diaphragm connected with the outer periphery of said frame, said diaphragm moving in accordance with movement of said voice coil.

2. A loudspeaker apparatus according to claim 1, wherein a projected area of said yoke on said diaphragm is a half or less of the effective area of said diaphragm.

3. A loudspeaker apparatus according to claim 2, wherein said yoke acts as an equalizer and

has a shape and size sufficient for obtaining an appropriate equalizing effect.

4. A loudspeaker apparatus according to claim 1, wherein said magnet is a magnet ring which is polarized in a radial direction.

5. A loudspeaker apparatus according to claim 4, wherein said magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

6. A loudspeaker apparatus according to claim 1, further comprising a heat dissipating means for dissipating heat generated in said voice coil and said yoke.

7. A loudspeaker apparatus according to claim 6, wherein said heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins.

8. A loudspeaker apparatus according to claim 6, wherein said heat dissipating means is a plurality of heat dissipating fins which are formed as part of said yoke.

9. A loudspeaker apparatus comprising:
a yoke having a pot-like shape, said yoke including an outer peripheral wall and an inner peripheral wall, said walls being formed concentrically with each other;
a frame disposed in front of said yoke, the inner periphery of said frame connected with said yoke;
a magnet attached to the inner side face of said outer peripheral wall;
a voice coil inserted into a gap between said magnet and said inner peripheral wall, said voice coil moved along the direction of the center axis of said yoke by interaction between a magnetic field formed by said magnet and a current flowing through said voice coil;
a diaphragm, the inner periphery of said diaphragm connected with said voice coil, the outer periphery of said diaphragm connected with the outer periphery of said frame, said diaphragm moving in accordance with movement of said voice coil; and
a heat dissipating means for dissipating heat generated in said voice coil and said yoke.

10. A loudspeaker apparatus according to claim 9, wherein said heat dissipating means is a heat dissipating member which has a plurality of heat dissipating fins.

11. A loudspeaker apparatus according to claim 9, wherein said heat dissipating means is a plurality of heat dissipating fins which are formed as part of said yoke.

12. A loudspeaker apparatus according to claim 9, wherein said magnet is a magnet ring which is polarized in a radial direction.

13. A loudspeaker apparatus according to claim 12, wherein said magnet is selected from a group consisting of a samarium-cobalt magnet, a cerium-cobalt magnet and a neodymium magnet.

Fig. 1

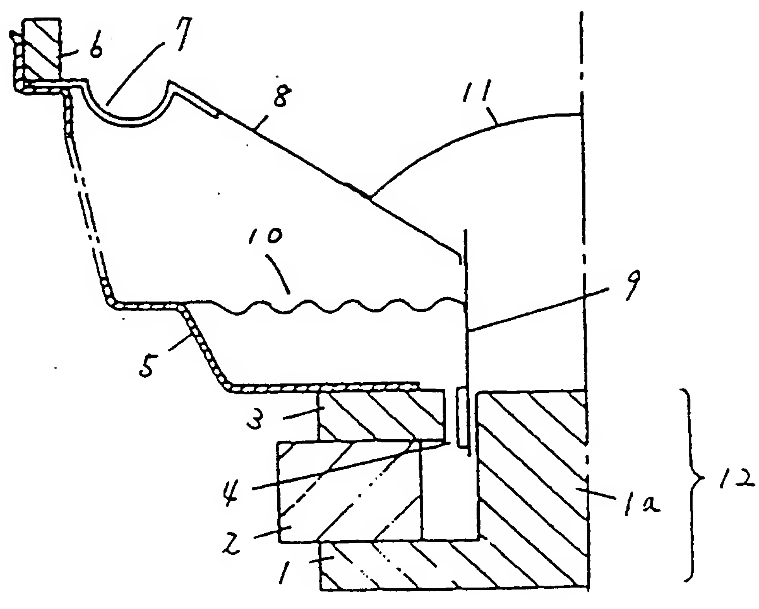


Fig. 2

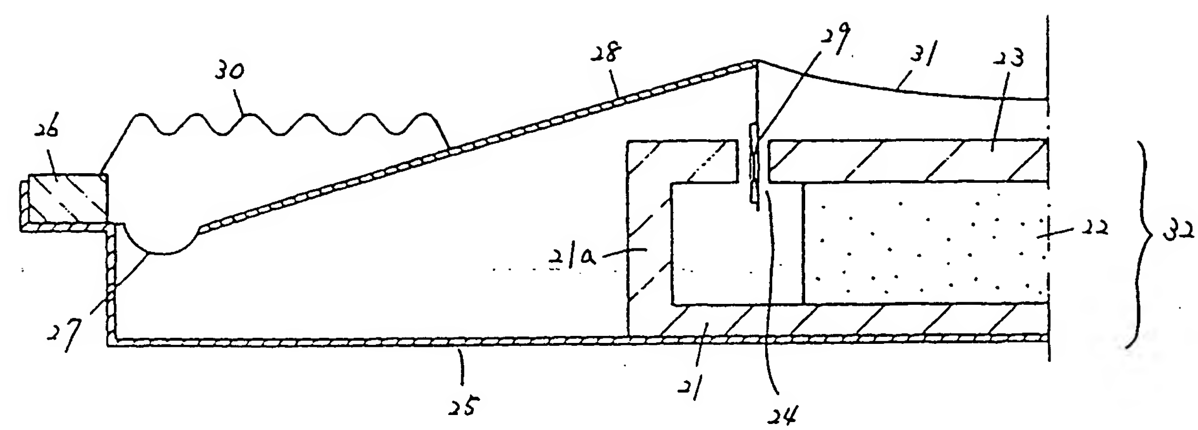


Fig. 3

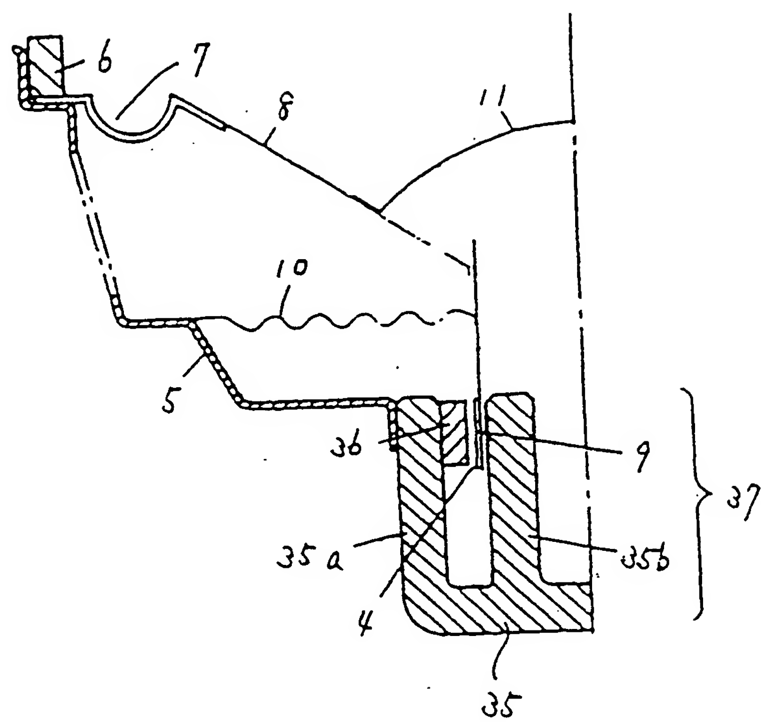


Fig. 4

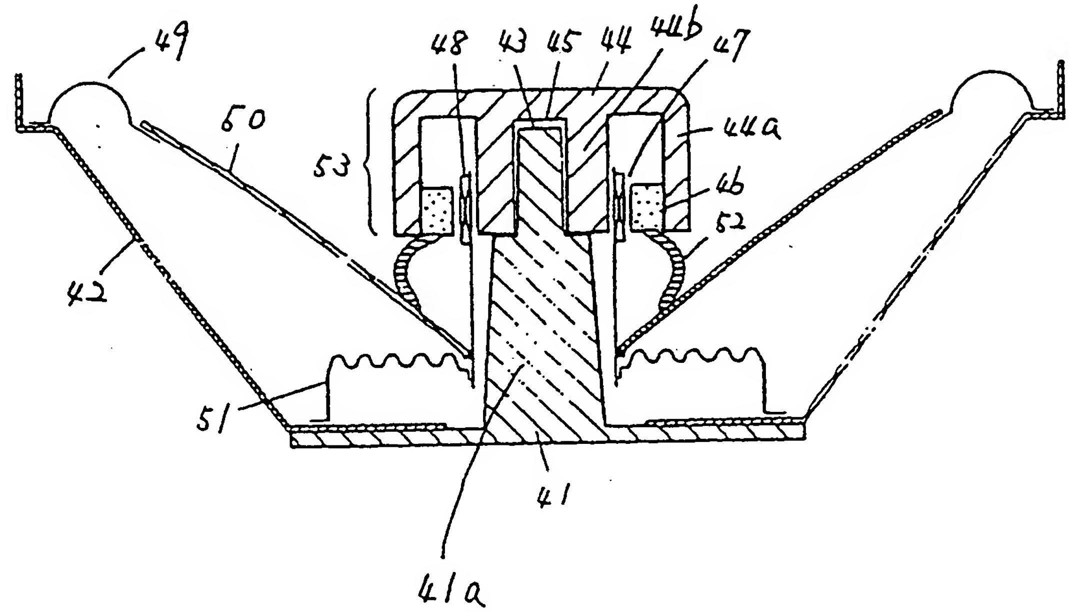


Fig. 5

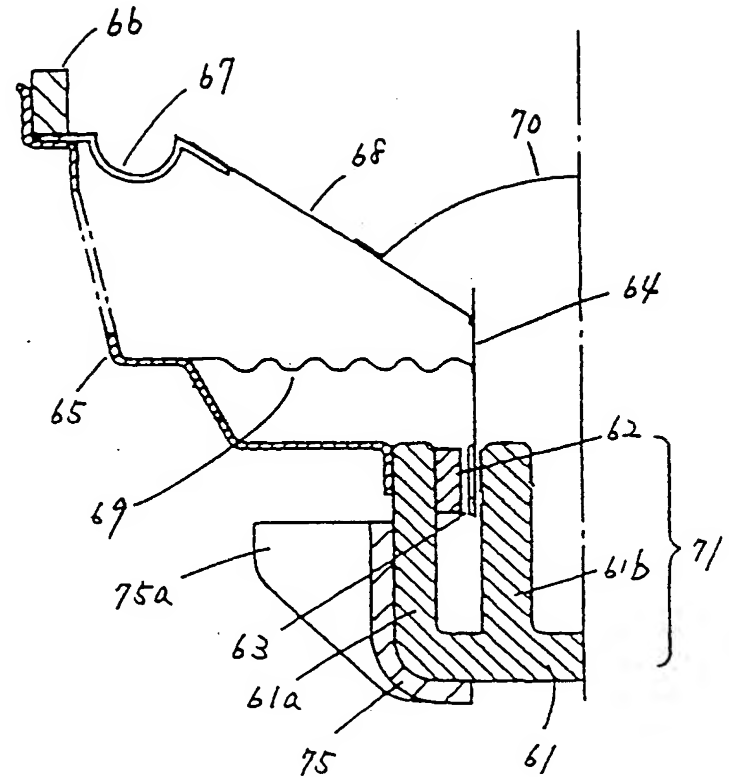


Fig. 6

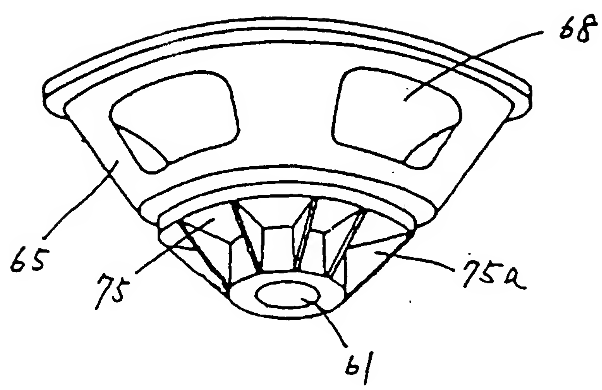


Fig. 7A

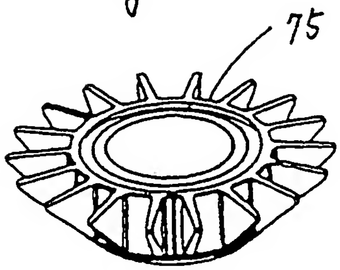


Fig. 7B

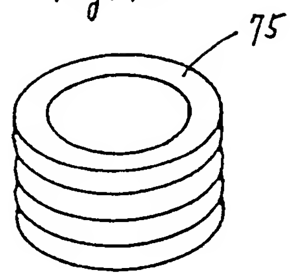


Fig. 7C

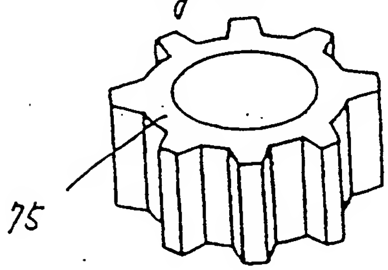


Fig. 7D

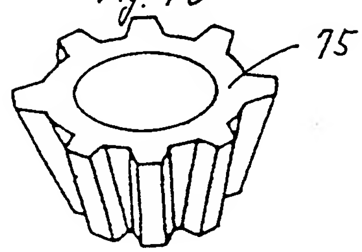


Fig. 8

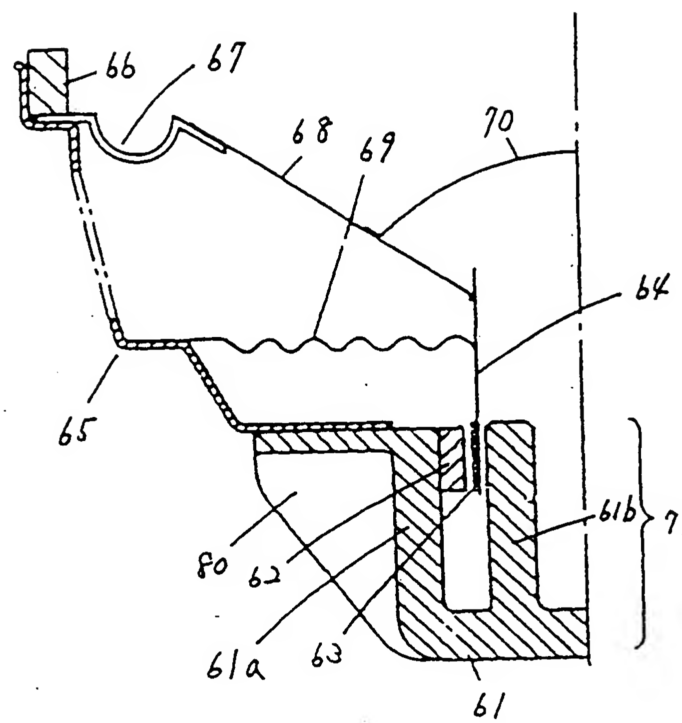


Fig. 9

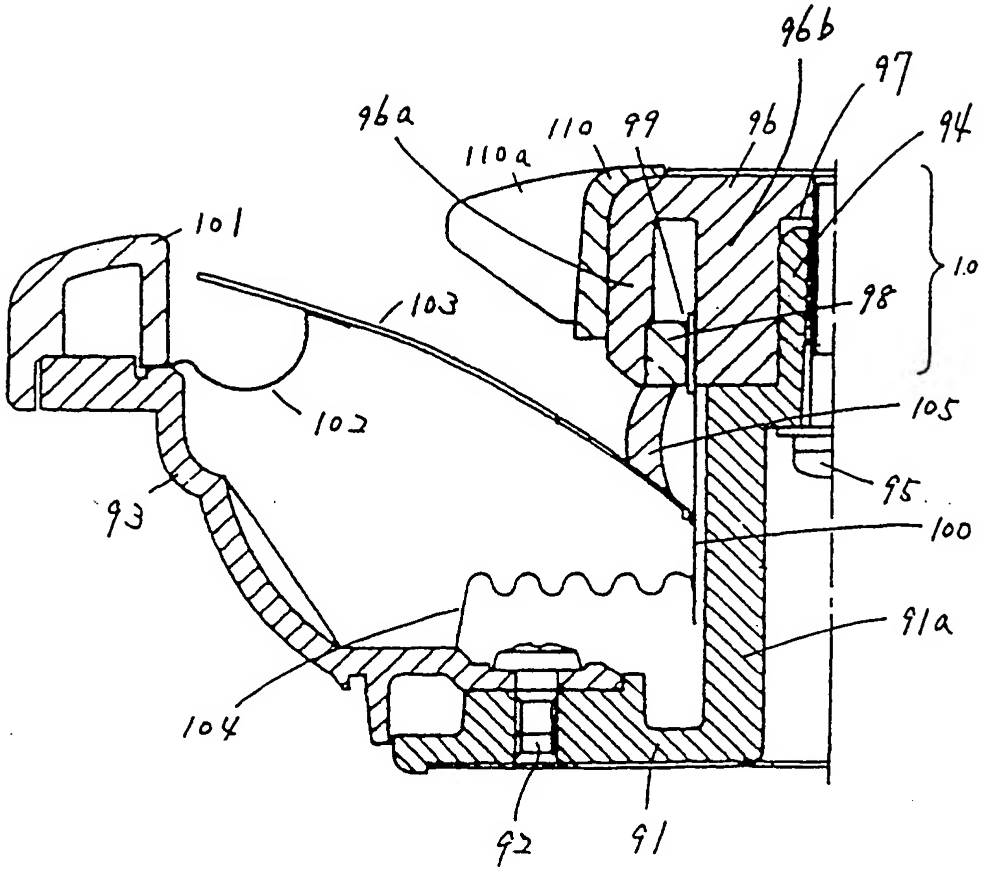

96b
97
96a
110
99
96
94
110a
101
106
103
98
102
105
95
93
100
91a
104
92
91

Fig. 10

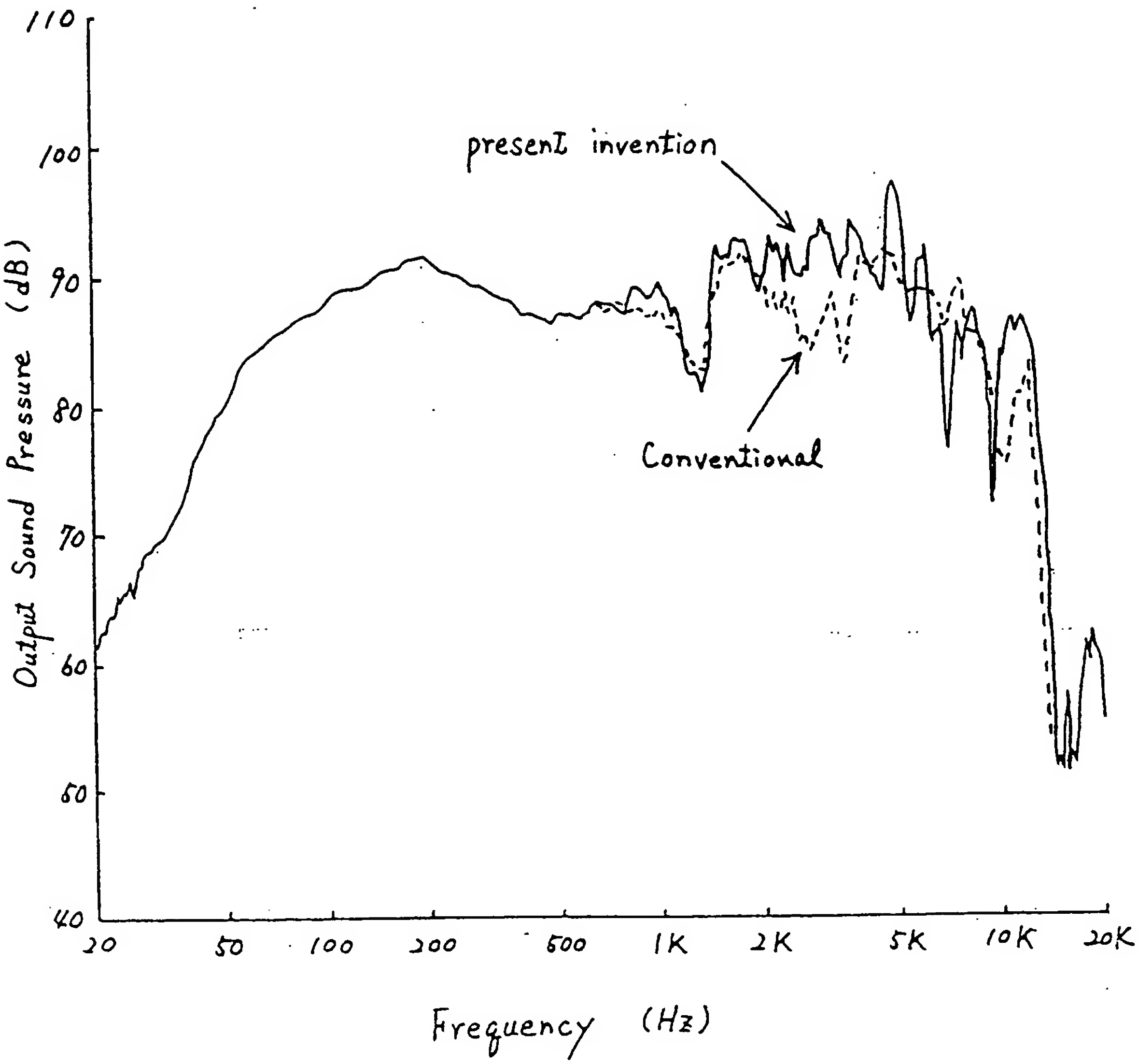
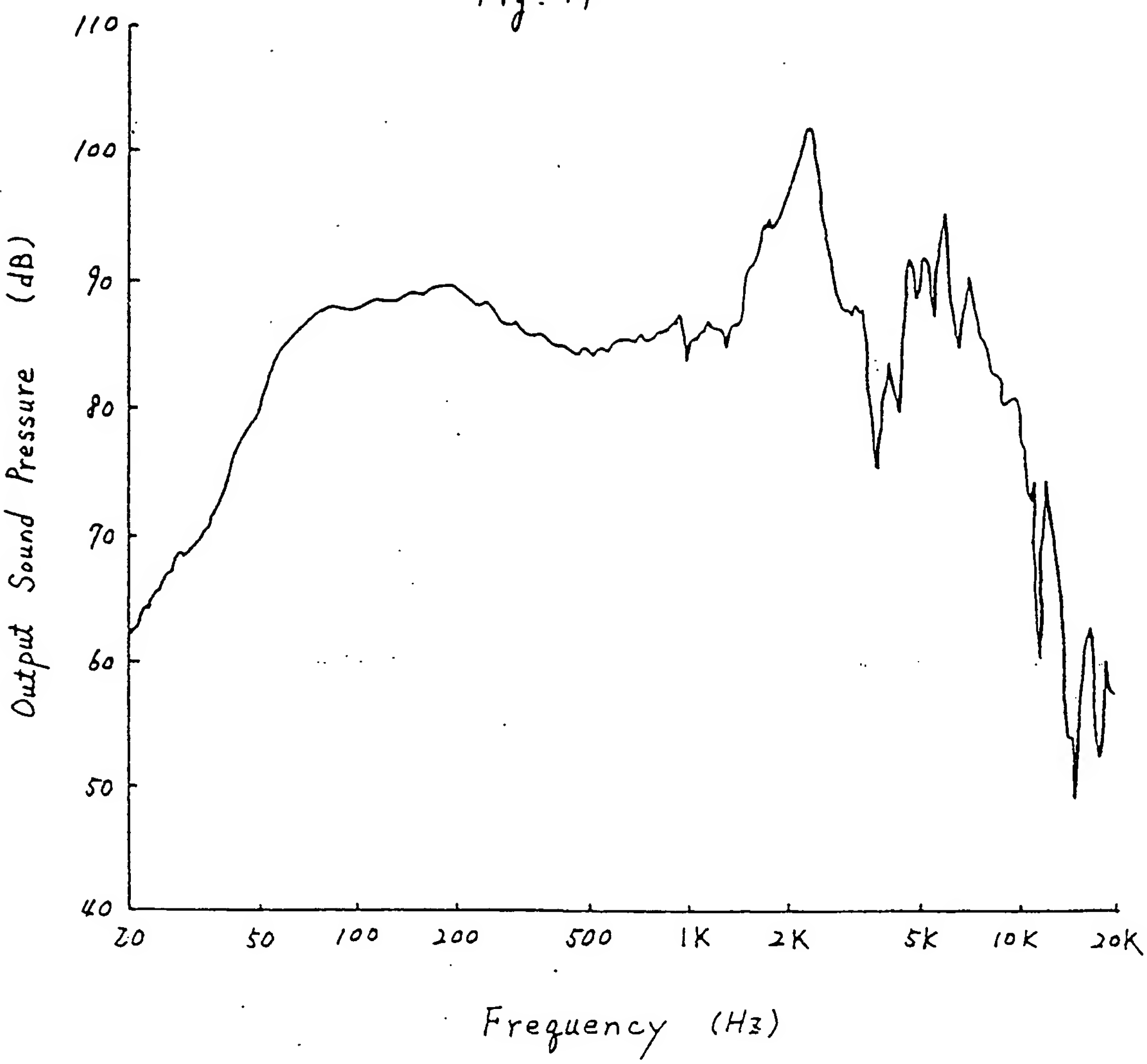

110
100
90
80
70
60
50
40
Output Sound Pressure (dB)
present invention
Conventional
20
50
100
200
500
1K
2K
5K
10K
20K
Frequency (Hz)

Fig. 11


110
100
90
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70
60
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Output Sound Pressure (dB)
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1K
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10K
20K
Frequency (Hz)

(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 624 049 A3**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94106578.1**

(22) Date of filing: **27.04.94**

(30) Priority: **28.04.93 JP 102308/93**
04.06.93 JP 134493/93

(43) Date of publication of application:
09.11.94 Bulletin 94/45

(84) Designated Contracting States:
DE FR GB

(88) Date of deferred publication of the search report:
08.03.95 Bulletin 95/10

(51) Int. Cl.[6]: **H04R 9/06**, H04R 9/02

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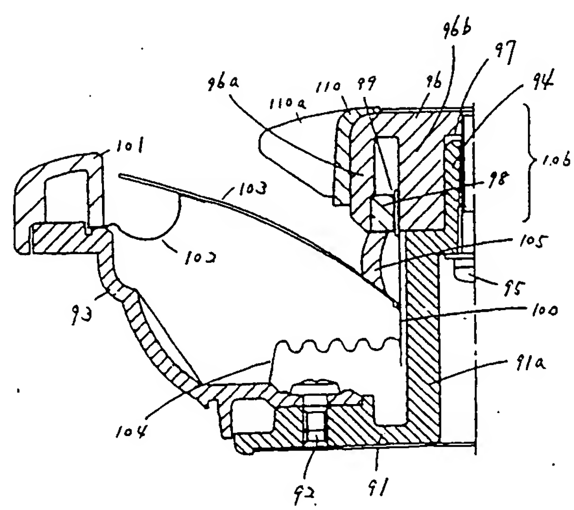
(54) A loudspeaker apparatus.

(57) A yoke (96), which has an inner peripheral wall (96b) formed concentrically with an outer peripheral wall (96a), is used in a magnetic circuit of a loudspeaker. A rare earth element magnet ring (98) is disposed between the outer and inner peripheral walls of the yoke (96) so as to form a magnetic gap (99) there. Thus, a compact, light and powerful magnetic circuit is obtained. The magnetic circuit is disposed in front of a diaphragm (103), which reduces the thickness of the loudspeaker. By making the projected area of the magnetic circuit on the diaphragm a half or less of the effective area of the diaphragm, deterioration of the performance properties and the quality of reproduced sounds can be avoided. Moreover, a heat dissipator (110) is provided on the yoke (96) so as to prevent any extraordinary or damaging increase in temperature of a voice coil even when large signals are continuously input to the loudspeaker. As a result, performance properties of the loudspeaker can be stabilized and reliability thereof can be enhanced.

Fig. 9



EP 0 624 049 A3

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EUROPEAN SEARCH REPORT

Application Number
EP 94 10 6578

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
Y A	DE-A-41 26 121 (MAC AUDIO ELECTRONIC GMBH) * column 3, line 42 - column 4, line 6; figure *	1 5	H04R9/06 H04R9/02
Y A	WO-A-93 03586 (AURA SYSTEMS, INC.) * page 10, line 13 - page 11, line 17; figure 4 *	1,9 4,12	
Y A	US-A-4 327 257 (SCHWARTZ) * column 10, line 61 - column 11, line 4; figures 15,16 * * column 7, line 56 - line 64; figure 1 *	9 1,10,11	
A	DE-A-36 38 693 (BOSE CORP.) * column 2, line 53 - column 3, line 27; figures 1-3 *	1,5,13	
A	DE-A-30 07 991 (ELEKTROTECHNIK EHMANN GMBH) * page 10, line 24 - page 12, line 10; figure *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	US-A-4 933 975 (BUTTON) * column 4, line 1 - line 65; figures *	6,7	H04R
A	US-A-3 763 334 (PARKER) * column 2, line 3 - column 3, line 7; figures *	9	
A	US-A-4 379 951 (GABR) * column 11, line 15 - line 22; figure 27 *	9	
A	FR-A-2 667 212 (P.H.L. AUDIO) * figure *	9	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 December 1994	Gastaldi, G

CATEGORY OF CITED DOCUMENTS

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Y : particularly relevant if combined with another document of the same category
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

European Patent Office

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

☐ All claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for all claims.

☐ Only part of the claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid.

namely claims:

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions.

namely:

see sheet -B-

☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid.

namely claims:

☐ None of the further search fees has been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims.

namely claims:

European Patent Office

EP 94 10 6578 -B-

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirement of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims 1-8 : A loudspeaker comprising: a supporting member having a center pole; a frame connected with the supporting member; a yoke having a pot-like shape, said yoke being attached at the top end of the center pole; a magnet; a voice coil; a diaphragm.

2. Claims 9-13 : A loudspeaker comprising: a yoke having a pot-like shape; a frame; a magnet; a voice coil; a diaphragm; a heat-dissipating means.